Dentine Lead Levels in Asymptomatic Philadelphia School Children: Subclinical Exposure in High and Low Risk Groups*

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Dentine lead levels were measured in 760 asymptomatic school children from two school districts, one considered high risk for lead exposure, one considered low risk. Elevated levels were found in black children living in deteriorated housing and in those white children from housing in good repair who lived and attended school in proximity to major manufacturer of paint and lead products.

Whether subclinical exposure to lead produces significant neuropsychologic impairment is a critical question, raised frequently by students of lead poisoning, and recognized as crucial to the setting of proper standards for both treatment and environmental prevention of exposure. The precise effects of low level exposure have to date escaped direct and systematic measurement for at least three reasons: (1) the nonspecific, and therefore easily missed effects of lead on the central nervous system; (2) the many variables known to affect development of the growing child which confound the relationship of lead to outcome; (3) the lack of a reliable index of past exposure to the metal.

If a reliable index of past exposure were available, it would allow the conduct of large scale epidemeologic studies in which other factors known to affect neuropsychologic behavior could be identified and controlled, permitting the relationship between lead exposure and performance then to be measured. Because blood lead levels decline once exposure ceases, they are unsuitable as retrospective indices in school age children. We suggest that the measurement of lead concentrations in the circumpulpal dentine of shed deciduous teeth provides the required marker of the child's history of exposure.

In 1964, Altshuler and her colleagues, measuring whole tooth lead concentrations, found substantial elevations in the teeth of lead-poisoned children who died of the disease, and in survirors (*1*). In 1970, we collected 109 teeth from Philadelphia children considered asymptomatic for lead poisoning, 69 from children residing in the "lead belt" of the inner city and 40 from children living in the suburbs (*2*). Residents of the lead belt had five times the mean concentration of whole tooth lead compared to their

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suburban counterparts. (Lead belt $\overline{X}$ = 51.1 $\mu g/g$, suburbs X = 11.0 $\mu g/g$) Three children who recovered from lead intoxication who gave teeth had concentrations of 110, 92, and 62 $\mu g/g$. Fifteen, or 23% of the 69 lead belt children, had levels equal or greater than these three.

Studies of the microdeposition of lead in teeth, employing both electron probe analysis (*3*) and chemical methods (*4*), showed that lead is concentrated in the zone of dentine immediately adjacent to the pulp. Because dentine in this area is laid down from the time of eruption to exfoliation, concentrations measured here reflect exposure throughout that period.

Dissecting out this zone, we then measured lead concentrations in 9 lead-poisoned children long after recovery, 20 asymptomatic children from suburban Boston, and 17 healthy Icelandic children. Striking differences were discovered (Table 1).

Table 1.

	N	Lead concentrations ± S.D., $\mu g/g$
Lead-poisoned	9	601±225
Suburban Boston	20	84.4±56.6
Icelandic	17	35.9±29.8

The lowest dentine lead level observed in a child with overt poisoning was 292 $\mu g/g$ (*5*).

Strehlow's studies in the primate of recovery of ^{210}Pb up to 15 months after pulsed injection of the isotope have confirmed that storage of lead is dose-related, permanent, and unaffected by chelation with either EDTA or BAL (*6*).

Method

In 1970, we collected, with the generous cooperation of the Philadelphia public and parochial school systems, 760 shed deciduous teeth from asymptomatic first graders. Two school districts, 8 and 5, were selected for this study on the basis of known differences in reported lead poisoning.

District 8, in Northeastern Philadelphia consists in the main of houses built since World War II. The population is predominantly white. Reports of lead poisoning are vanishingly rare from this area. Four public schools and one parochial school were enrolled from this District.

The western half of District 5 has a high density of older deteriorated homes. The population is predominantly black. Many of the city's cases of lead poisoning are reported from this area. Six public schools were enrolled from this sector. The eastern half of District 5 is highly industrialized, the population predominantly white. Housing is old, but in generally good repair. Reported lead poisoning is rare in this sector. Three parochial schools were enrolled from this area.

Samples of dust from inside the schools, playground and gutter dirt were also obtained, in the spring of 1973, for analysis.

After the teeth were collected, they were stored in dry glass tubes until ready for analysis. Teeth were embedded in acrylic, and a 500 × 300 μ section of circumpulpal dentine was dissected out, weighed, and analyzed for lead by anodal stripping voltammetry (*7*).

Results

Sharp differences between the mean dentine lead levels of the public schools of District 5 and 8 were found. Of particular interest were the elevated dentine lead levels in the parochial schools of District 5, particularly St. A's (Fig. 1).

Figure 2 shows the cumulative frequency distribution of dentine lead levels for public and parochial students. While only 3% of the public and 6.6% of the parochial school students of District 8 had dentine lead concentrations greater than 100 $\mu g/g$, 66% of the black public school students and 43% of the white students of St. A's had levels in excess of 100 $\mu g/g$. Of black students from District 5, 19% had dentine levels in the range associated with frank lead poisoning (>300 $\mu g/g$), and lead levels in 8.4% of St. A's students also exceeded 300 $\mu g/g$ (Table 2).

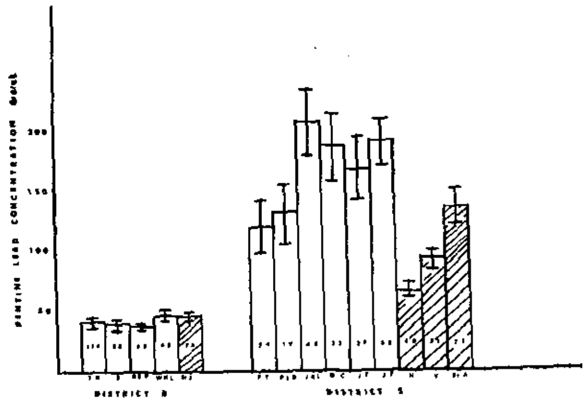

FIGURE 1. Mean (± SEM) dentine lead levels by school. Cross-hatched columns denote parochial schools. Number of subjects indicated within column.

Table 3 shows the dust and dirt concentration found in the two school districts, and in two suburban schools for comparison. Substantial elevations of lead were found in District 5.

Discussion

These data portray a prevalence of exposure to lead in at-risk groups greater than heretofore reported. They also show that other groups than those ordinarly acknowledged have elevated body lead burdens. While 7–12% of high risk groups studied are reported to have blood lead levels in the range associated with hazard (above 60 μg/g) (*8*), our data show that 66% of black children from the Philadelphia lead belt have elevated dentine levels, with 19% in the range found with clinical lead poisoning.

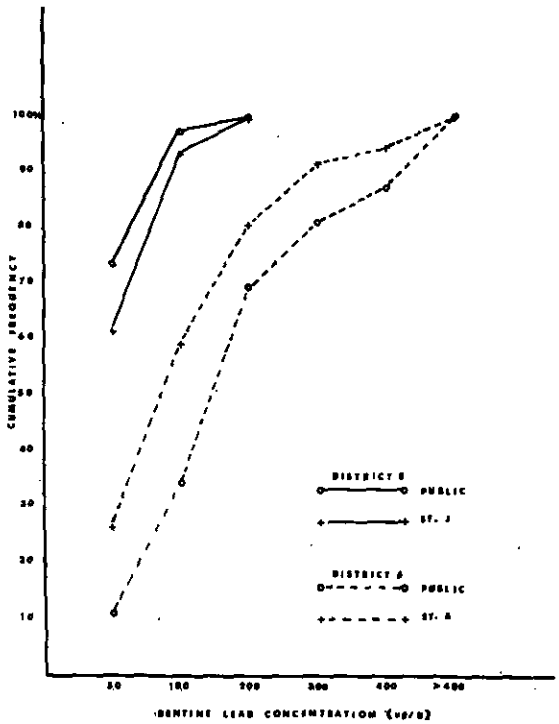

FIGURE 2. Frequency distribution of students by dentine lead concentration.

The elevated lead levels in the white parochial school children attending St. A's were unexpected and lead us to examine the surrounding neighborhood. This area has a high concentration of metal fabricators and smelters. Located one city block to the Southeast of the school is a major paint manufacturer

Table 2. Distribution of students by dentine lead concentration.

		No. (%) of students at various ranges of dentine lead concentrations					
	N	0–50 μg/g	51–100 μg/g	101–200 μg/g	201–300 μg/g	301–400 μg/g	>400 μg/g
District 8							
Public schools	303	221(73%)	74(24%)	9(3%)			
Parochial, St. J.	76	47(62%)	24(32%)	5(7%)			
District 5							
Public schools							
Black	174	17(11%)	40(23%)	62(36%)	14(11%)	12(7%)	22(13%)
Latin	37	9(24%)	12(32%)	11(29%)	4(11%)	1(3%)	
Parochial, St. A.	71	19(27%)	23(32%)	15(21%)	8(11%)	2(3%)	4(6%)

Table 3. Lead in environmental samples.

School	Lead concentration, µg/g		
	Interior dust	Playground dirt	Gutter dirt
District 8			
T. H.	835	403	2626
R. B. P.	293	444	270
W. H. L.	939	424	1603
St. J.	388	421	1528
District 5			
V.	2838	8683	3031
	929	—	—
St. A.	3074	—	8201
	4947	—	6340
P. T.	1889	—	2392
	3782	—	—
P. L. D.	15680	761	—
	2066	493	—
J. R. L.	5327	2578	2729
	3388	533	—
G. C.	3411	3252	280
	1206	983	—
J. E.	3666	17256	4332
	4416	—	—
J. F.	3206	1207	1515
	1854	—	537
Suburban			
H.	1517	88	1359
	946	67	834
L.	579	38	550
	277	118	714

and fabricator of lead compounds. The finding of elevated levels in this school group is consistent with McIntyre and Angle's report (*9*) of higher blood lead levels in children attending school in proximity to a lead smelter and confirms the statement of the National Academy of Science's Task Force on Lead: "The swallowing of lead contaminated dusts may well account in large part for the higher mean blood lead content in urban children, and the rather large fraction whose blood lead content falls in the range of 40–60 µg/100 ml" (*10*). Our data show that children in intimate proximity to lead processors may experience severe enough exposure to raise their body lead burdens to the range associated with toxicity.

In addition to industrial sources of lead, the entire area of District 5 is subject to extremely heavy automobile traffic. The District is bounded on the West by Broad Street, a six-lane North-South conduit, and on the East by Interstate 95. These roads are paralleled and crossed by a large number of heavily traveled truck and auto routes.

The unexpected finding of elevated dentine lead levels in children in housing of good repair but living and attending school close to a major lead processor and the anticipated finding of elevations in children who live in deteriorated housing both suggest that both lead in paint and airborne lead are involved and that children living in deteriorated housing are in fact being exposed to both sources.

The measurement of dentine lead levels, by identifying past exposure to lead, provides a means to conduct large-scale retrospective cohort studies in which the relationship of subclinical exposure to health can be determined, controlling, of course, for other important variables known to affect the development of growing children.

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